HEALTH AND ENVIRONMENT INTERNATIONAL TRUST

2 June 2012

Climate Data and Heat Exposure Software: Hothaps-Soft v 1.0.2.4

User Manual

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Background

Identifying current and estimating future heat exposures, researchers can access weather station data from several sources. Many are available free of charge on the Internet. The data comes in various formats, depending on the collecting agency, and always involves a large number of steps converting raw data into meaningful values before they are ready for evaluation, research and publishing.

One of the most comprehensive collections of global weather data is being held by the National Oceanic and Atmospheric Administration (NOAA), and daily readings are freely available under http://www7.ncdc.noaa.gov/CDO/dataproduct. This software application uses the "Surface data, Global Summary Of the Day (GSOD)" data set. GSOD contains humidity data, which is essential for estimation of human heat exposures. For validation and comparison grid cell data provided by the Climate Research Unit (CRU-3) is also used.

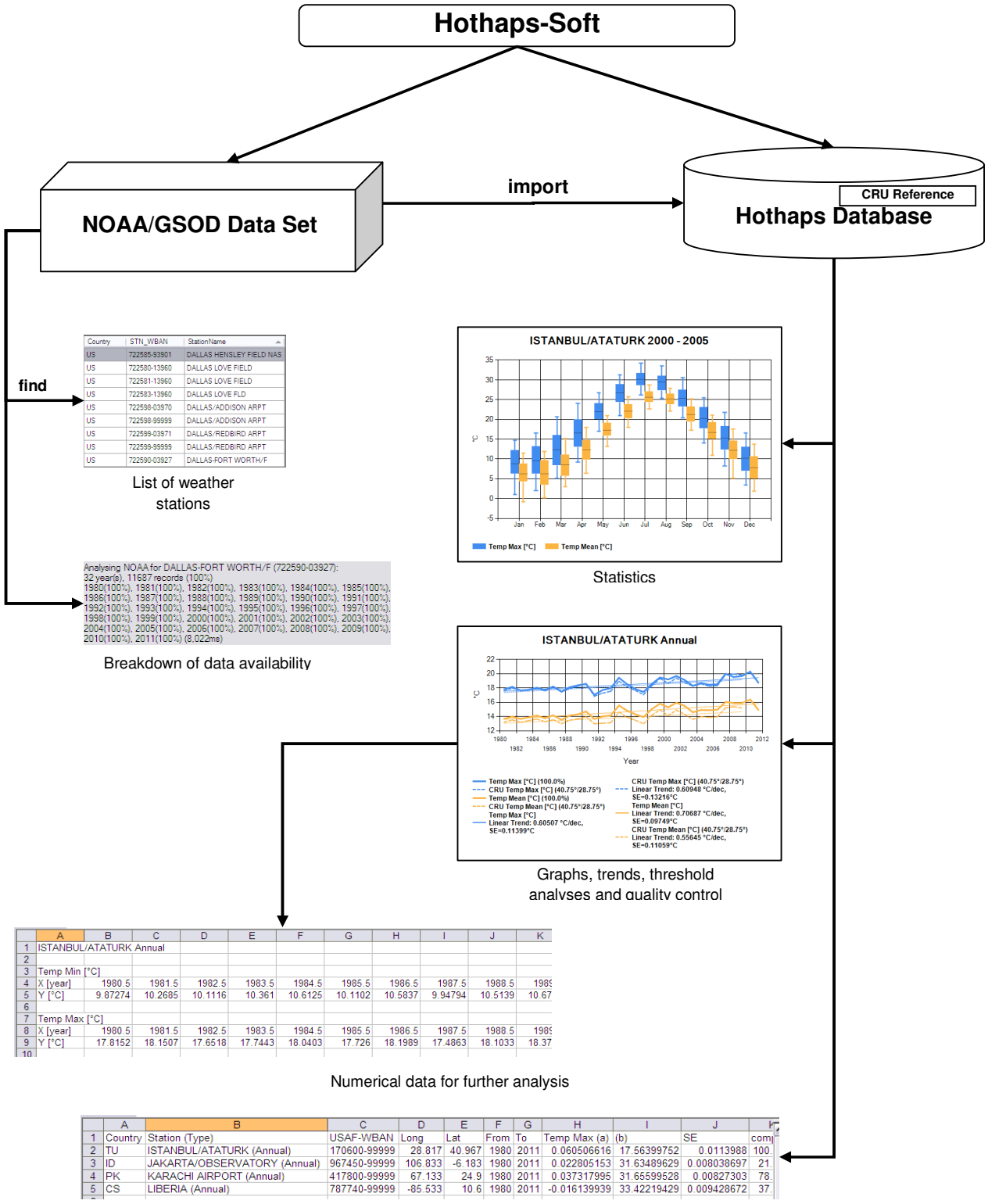
This manual walks you through the basic functionality of the software. It provides information on the menu items and choices, as well as ways to customise the output. There are many permutations and combinations of commands and uses of this application, not all of which can be shown here. Also, features and specifications are subject to change as a matter of improving the software.[1]

What this software can do and output examples

- Analyse the availability and data density of readily available routine weather station data
- Produce customisable graphs, trends and statistical analysis of raw weather data as well as calculated heat exposure indexes
- Provide a comparison of weather station data (NOAA/GSOD) with CRU-3 grid cell data.
- Extract any part of the data in numerical form for further analysis

[1] Some screenshots used in this manual may show an earlier version number in the heading. In these cases there are no significant differences in the functionality compared to the current version.

An overview of the entry point and different pathways



Country	STN_WBAN	StationName
US	722585-93901	DALLAS HENSLEY FIELD NAS
US	722580-13960	DALLAS LOVE FIELD
US	722581-13960	DALLAS LOVE FIELD
US	722583-13960	DALLAS LOVE FLD
US	722598-03970	DALLAS/ADDISON ARPT
US	722598-99999	DALLAS/ADDISON ARPT
US	722599-03971	DALLAS/REDBIRD ARPT
US	722599-99999	DALLAS/REDBIRD ARPT
US	722590-03927	DALLAS-FORT WORTH/F

	A	B	C	D	E	F	G	H	I	J	K
1	ISTANBUL/ATATURK Annual										
2											
3	Temp Min [°C]										
4	X [year]	1980.5	1981.5	1982.5	1983.5	1984.5	1985.5	1986.5	1987.5	1988.5	1989
5	Y [°C]	9.87274	10.2685	10.1116	10.361	10.6125	10.1102	10.5837	9.94794	10.5139	10.67
6											
7	Temp Max [°C]										
8	X [year]	1980.5	1981.5	1982.5	1983.5	1984.5	1985.5	1986.5	1987.5	1988.5	1989
9	Y [°C]	17.8152	18.1507	17.6518	17.7443	18.0403	17.726	18.1989	17.4863	18.1033	18.37
10											

	A	B	C	D	E	F	G	H	I	J	K
1	Country	Station (Type)	USAF-WBAN	Long	Lat	From	To	Temp Max (a)	(b)	SE	comp
2	TU	ISTANBUL/ATATURK (Annual)	170600-99999	28.817	40.967	1980	2011	0.060506616	17.56399752	0.0113988	100.
3	ID	JAKARTA/OBSERVATORY (Annual)	967450-99999	106.833	-6.183	1980	2011	0.022805153	31.63489629	0.008038697	21.
4	PK	KARACHI AIRPORT (Annual)	417800-99999	67.133	24.9	1980	2011	0.037317995	31.65599528	0.00827303	78.
5	CS	LIBERIA (Annual)	787740-99999	-85.533	10.6	1980	2011	-0.016139939	33.42219429	0.009428672	37.

Common Workflow Scenarios

A. Plot data you commonly use, i.e. data already in the *database*

1. Start software, go to **Chart** or **Chart SD** Tab, select station(s) and options, then produce a graph (page 9).
2. **Customise** graph (page 12).
3. **Export** graph for printing or publishing (page 15).
4. Alternatively right-click on station(s) and **export data** for further processing in a spreadsheet, database or other software (page 11).

B. Research arbitrary, new stations

1. Start software, select the **Manage Daily Data Tab** (page 6).
2. Try finding suitable stations by typing the name of city you are thinking of. Try different spellings, try part of the name. (NOAA station names are not consistent, nor are the always in English. Some stations are named after the name of an airport. There are several stations across the globe that share the same name.)
3. Use **country** filtering if in doubt. NOAA, and therefore Hothaps-Soft, uses FIPS country codes (http://en.wikipedia.org/wiki/FIPS_country_code).
4. If still unsure, look at the latitude/longitude readings. Use a map to verify. Try typing in the desired coordinates. Use the **Find Nearby** feature (page 7).
5. When you have found a number of plausible stations, perform an analysis on the station data (page 7).
6. If one or more stations of interest have sufficient data for your purposes (only years with more than 90% data completeness will be suitable for plotting and further processing), import them into the Hothaps database (page 8).
7. Continue with workflow scenario A

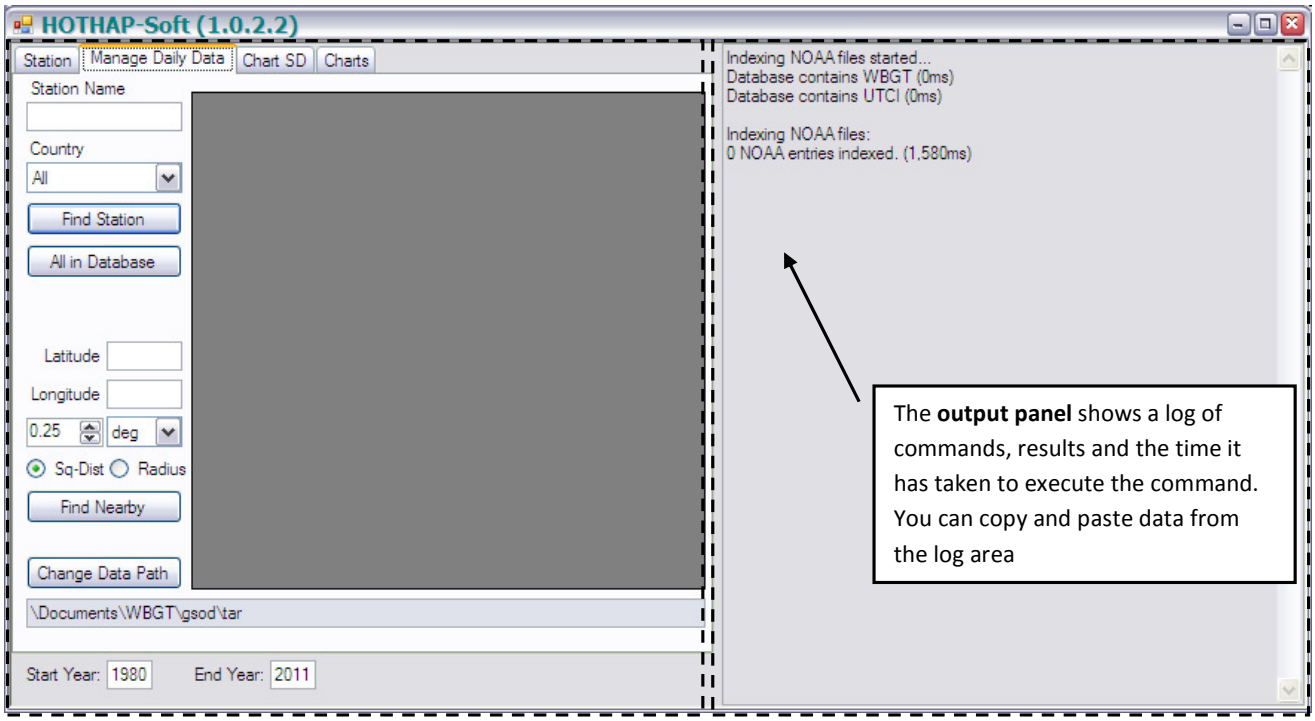
C. New NOAA weather station data has become available (typically at the beginning of a new year)

1. Go to ftp://ftp.ncdc.noaa.gov/pub/data/gsod/ and locate the latest complete year folder (i.e. in 2012 you would be clicking on the 2011 folder). Locate and download the gsod_YYYY.tar file at the bottom of the list (YYYY being the year in question). If you are sure that your NOAA data set doesn't have this file already, save/copy the file to the gsod folder that Hothaps is expecting (see page 7).
2. Start (or re-start Hothaps-Soft), select the **Manage Daily Data Tab** (see page 6).
3. Click **All in Database** to display your *current stations*. Highlight, say, 10 stations at a time and right-click **Import NOAA and Calc Chart Avgs** (page 8). This will add the new data to the database. When all the progress-bars have disappeared (this will take a few moments), repeat this for the next 10 stations, and so on, until you have updated all your stations. (In theory you could select all stations and do it all at once. Some systems seem to become unstable, so it seems safer to do it the described way.)
4. Proceed with scenario A or B.

Getting Started

To open the software double-click on **Start Hothaps-Soft** icon

The display has 2 parts: The lists, buttons and clickable areas to the left, and a grey output panel to the right.



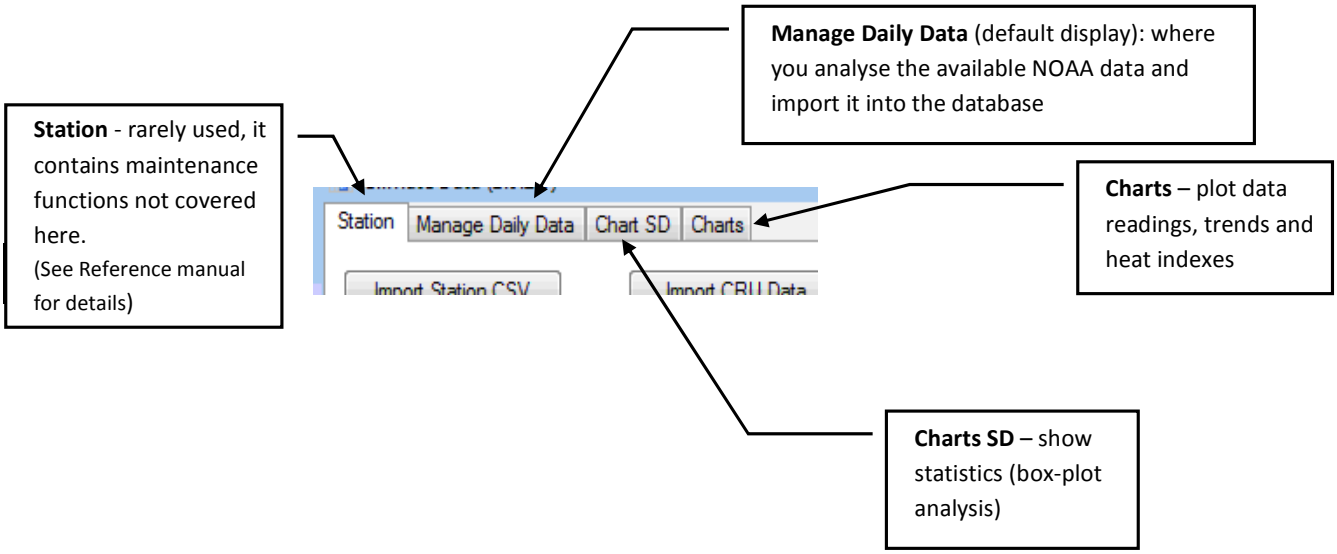
Start-Up

The program will carry out a number of routine activities and checks at start-up. These include validating the status of the Hothaps database, particularly whether WBGT and UTCI are included, and whether the NOAA/GSOD index (more information about NOAA data below) is up to date. This should take only a few moments if your database is up to date. In this case the output is shown in the output panel above.

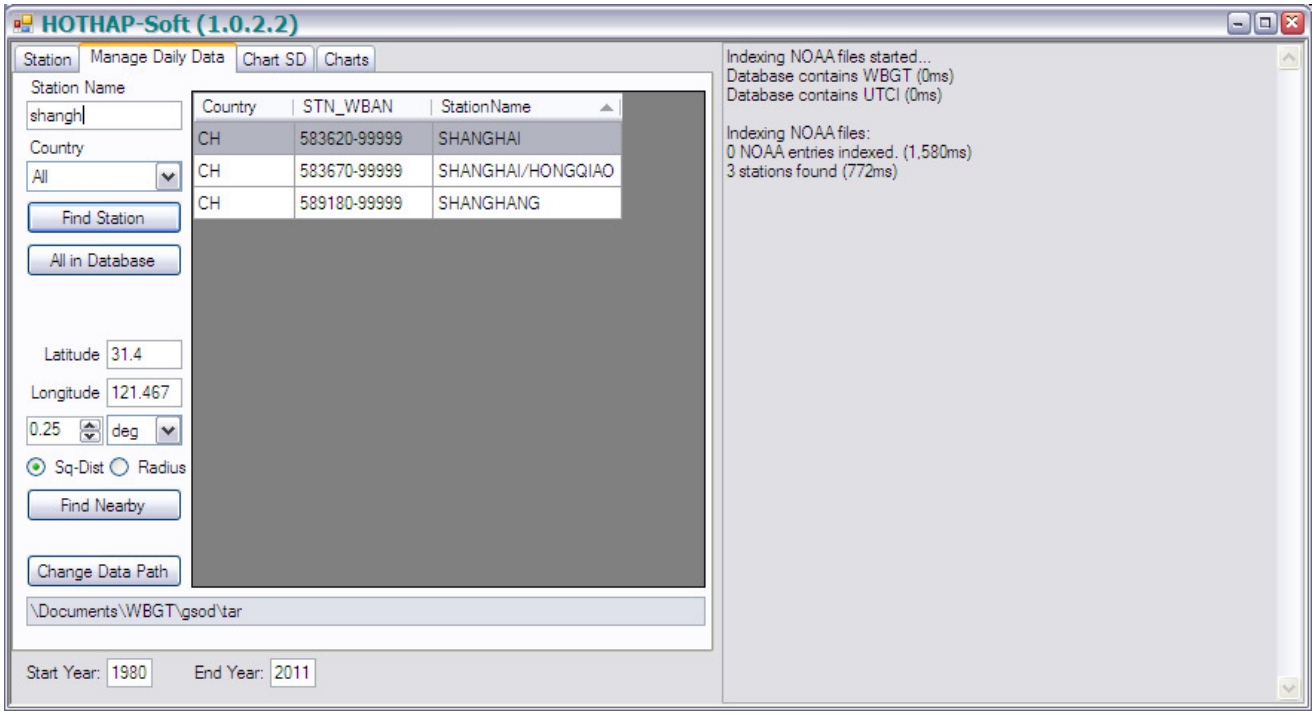
If you moved the location of the program or the NOAA data files, you will get an error message that no NOAA files could be found, or that it "Could not find part of the path". In case of any error message relating to NOAA indexing try changing the data path (see page 7 for details on changing the data path).

Any other error messages here usually indicate that the connection to the Hothaps database has not been established. There are potentially numerous reasons for those errors, and if the problems persist you should contact the developer for advice by providing a screenshot or copy of error message(s) and a brief explanation of the circumstances (e.g. which operation system was used, whether it used to work at some earlier stage etc.).

After start-up the software offers 4 tabs:


Station - rarely used, it contains maintenance functions not covered here.
(See Reference manual for details)
Manage Daily Data (default display): where you analyse the available NOAA data and import it into the database
Charts – plot data readings, trends and heat indexes
Charts SD – show statistics (box-plot analysis)
Station
Manage Daily Data
Chart SD
Charts
Import Station CSV
Import CRU Data

Manage Daily Data Tab



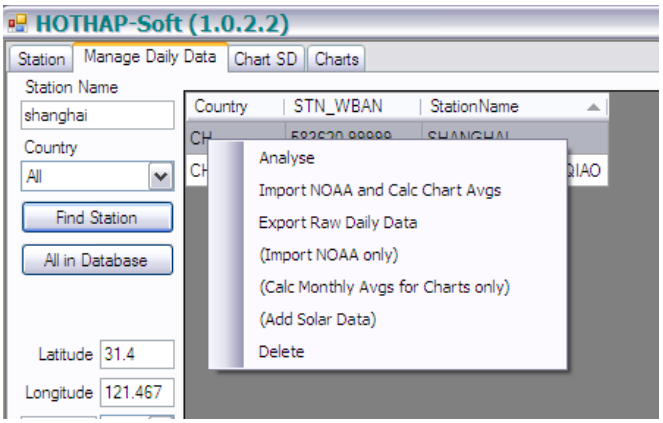
- To find a station by name, type any part of a station string into the text box and click the **Find Station** button (or press ENTER). The table will show the available stations with that name or part thereof (as above **shangh…**) and the station count is displayed in the output panel. The table shows the country code (e.g. CH), station number and name. If the results list is too large you can narrow your search by selecting a **Country**. Clicking **Find Station** (or pressing ENTER) with *nothing* in the Station Name box shows **all** stations in the selected country. (This may take a moment or two.)
- Clicking the **All in Database** button will show all stations for which data exists in the Hothaps database.

The station table can be sorted by clicking on any of the 3 headings, and reversed by clicking on the heading again.

Once a station is selected (highlighted) its *Latitude* & *Longitude* is displayed in the text boxes. You can override the longitude/latitude by typing in a geographical location for use with the following function:

- **Find Nearby**: This is where all stations in the vicinity are listed, using the specified distance from the displayed longitude/latitude:
    1. Enter a *number* to specify the distance to look for nearby stations. Choose the unit: *km, miles or degrees*.
    2. The search area may be a *circle* or a *square* around the currently displayed longitude/latitude. Example: If **1** is entered in the number field and **deg** as the unit and **Sq-Dist** is selected, the search area includes a field 1 degree north, east, south and west of the displayed longitude/latitude, effectively a 2 degree grid-square.
- **Change Data Path**: Tells the program where to find the NOAA data set. All NOAA data are expected to be stored in a single folder, in the form of gsod_YYYY.tar files, with YYYY the year of the records. As new annual data files become available copy them to this folder. At the start of the program, as well as after changing the NOAA data path using this button, the program will scan the files and re-index any entries not already in the Hothaps database.

Context Menu



Select one or more stations in the list (use Ctrl-Shift or Shift-Click for multiple selections). You access the ***context menu*** by right-clicking anywhere on the station list. (The following section covers only the essential menu items. Menu items in brackets are for special uses like diagnostics and are covered in the *Reference Manual.*)

- **Analyse**: Clicking **Analyse** will analyse the Hothaps database as well as the raw NOAA data for the selected station(s), producing two separate result sets shown in the output panel on the right. Each result set shows the number of years with any data in them, the number of records found in each year and the corresponding percentage of data density for those years, for example:

This SHANGHAI example shows that there are 20 years containing any data were found in the NOAA set between the years displayed in Start Year and End Year boxes at the bottom of the window. Relative to 20 complete years (20 x 365 = 7.300 records) the 7133 records found represent 97% data completeness in those years.

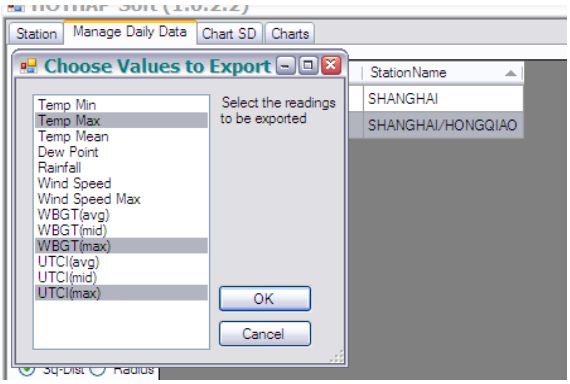
```
Analysing NOAA for SHANGHAI (583620-99999):
20 year(s), 7133 records (97%)
1991(55%), 1992(100%), 1993(100%), 1994(100%), 1995(100%), 1996(100%),
1997(100%), 1998(100%), 1999(100%), 2000(100%), 2001(100%), 2002(100%),
2003(100%), 2004(100%), 2005(100%), 2006(100%), 2007(99%), 2008(100%),
2009(100%), 2010(100%) (2,464ms)

Analysing DB for SHANGHAI (583620-99999):
0 year(s), 0 records (0%)
(6,392ms)
```

This is followed by a breakdown of the years containing data, showing the data density for each year in brackets. The second set of results ("Analysing DB for SHANGHAI") shows that there are no records in the Hothaps database. This means the station has not yet been imported.

- **Import NOAA and Calc Chart Avgs:** This is a common function, as it makes the weather station data available for use in this program. Use this when you want to work with this station and the analysis (above) shows either no records in DB, or the NOAA analysis shows more years than the DB analysis. The latter normally means that new NOAA data has been made available (downloaded and copied into the NOAA/GSOD folder) but has not yet been imported into the database.
- **Export Raw Daily Data:** Creates one comma-delimited text file containing daily records for each station selected, between the years displayed in **Start Year** and **End Year** boxes at the bottom of the window. Note that only data imported into the Hothaps database will be exported.

  After selecting this menu item the user is prompted for the desired values:

  You can select a single variable or any number of values by using Ctrl-Click or Shift-Click.

  Next, the user is prompted to select the location (folder) for the generated file(s). The filenames contain the station, years and the selected values, followed by the csv extension, e.g.:

  SHANGHAI-HONGQIAO 1980-2011 , Temp Max, WBGT(max), UTCI(max).csv

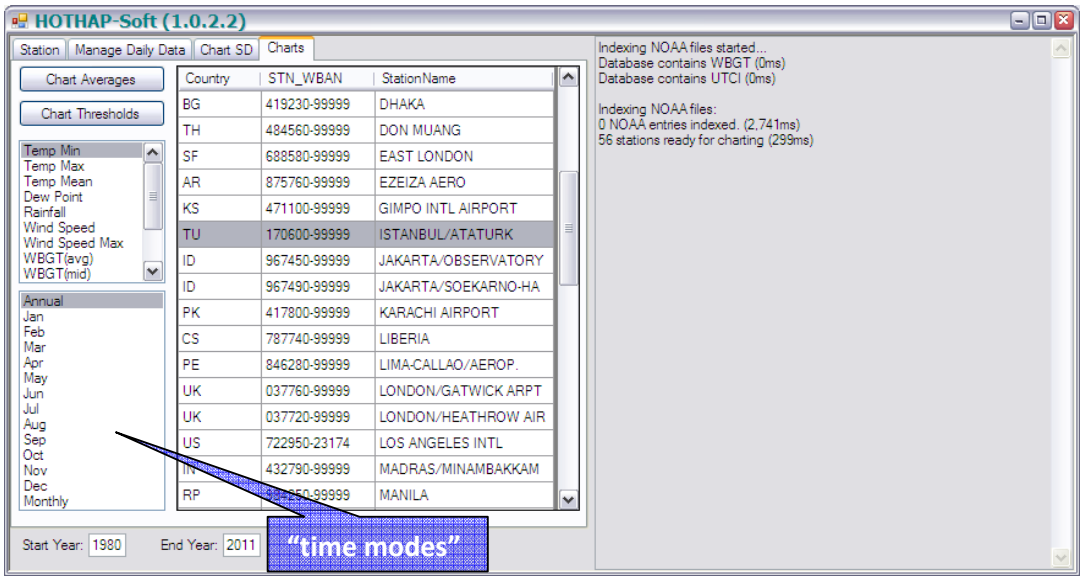
  When imported into an Excel spreadsheet this will produce suitable column headers as shown here:

	A	B	C	D	E
1	SHANGHAI/HONGQIAO (583670-99999)				
2	Rec Date	Temp Max	WBGT(max)	UTCI(max)	
3	1/01/1980	13	11.66	13.4985	
4	2/01/1980	9	7.77911	9.36501	
5	3/01/1980	7	5.86844	7.3331	
6	4/01/1980	5	2.78156	4.64476	
7	5/01/1980	10	6.00977	9.2267	
8	6/01/1980	8	5.052	7.57745	
9	7/01/1980	5	1.92544	4.25442	

- **Delete:** Deletes all daily data records and all monthly chart averages for the selected station(s) from the Hothaps database. The number of records deleted is reported in the log panel.
- Change the **Start Year** and **End Year**. The setting of Start and End Years affects:
  - *Analysis* of the *NOAA* data, but not the DB analysis.
  - *Import NOAA*
  - *Calc Monthly Avgs for Charts only*
  - *Import NOAA and Calc Chart Avgs*
  - *Export Raw Daily Data*

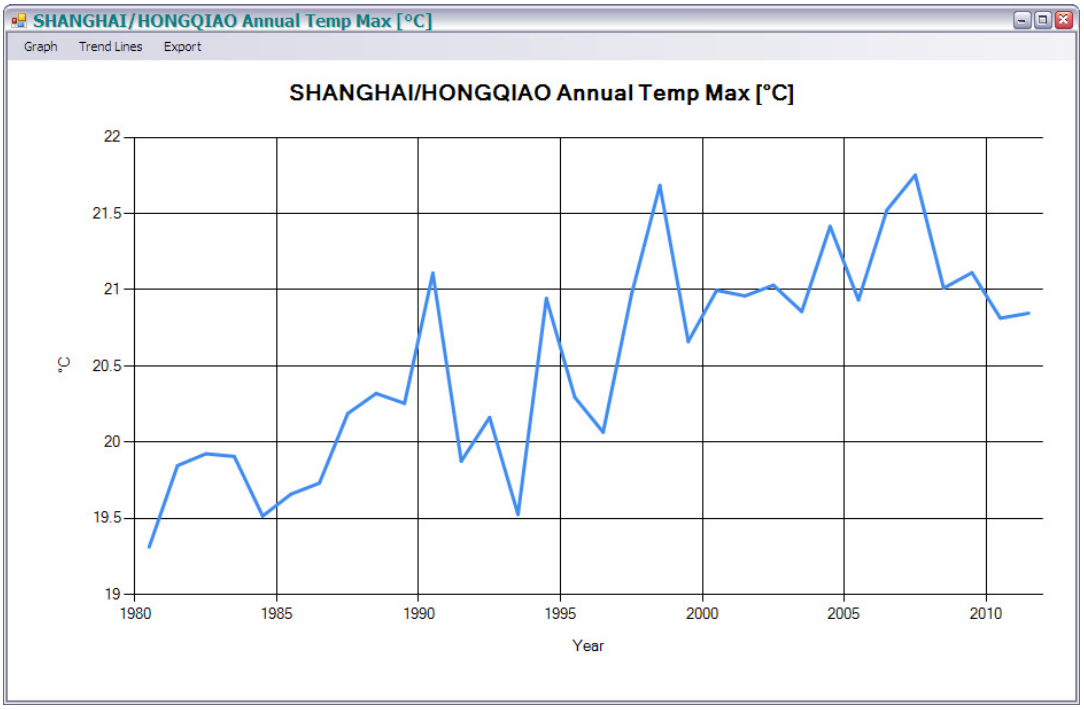
Charts Tab

The chart feature produces X, Y line charts in separate, resizable windows. You can customise many properties of the chart as outlined on page 12. It allows you to either produce charts based on *annual or monthly* ***averages***, or chart the *number of days per year a station exceeds a specified* ***threshold***.

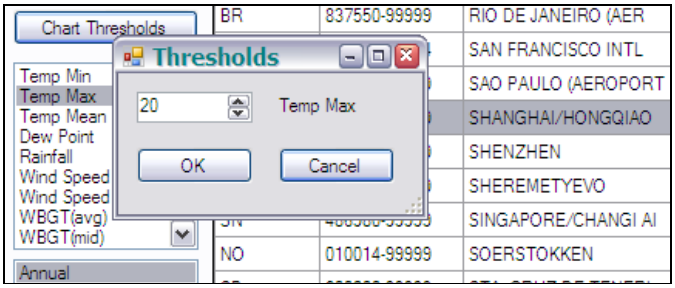


Select any combination (using Shift- or Ctrl-click) of **stations, values** or **"time modes"**, then click one of the buttons to create charts.

- **Chart Averages:** Produces a chart of averaged selected readings and/or heat indexes applied to the selected time modes and selected stations, between the years displayed in **Start Year** and **End Year** boxes at the bottom.



- **Chart Thresholds:** Produces a chart of the number of days where the selected actual daily readings and/or heat indexes exceed a threshold, applied to the selected time modes and selected stations, between **Start** and **End Year**. You will be prompted to enter a threshold value in a dialog box after clicking this button:

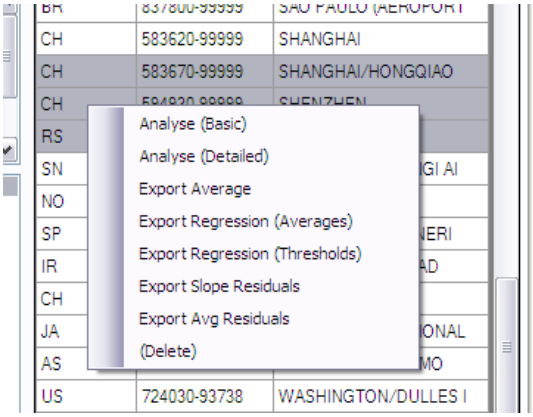


Time modes will produce the following charts:

- **Annual:** <u>One averaged value per year</u> for each reading and/or heat index (i.e. one data point per year)
- **Jan, Feb, Mar…**: <u>The averaged Jan or Feb or Mar… value for each year</u> (i.e. one data point per year)
- **Monthly**: <u>Each month's average</u>, (i.e. one data points per month)

Context Menu

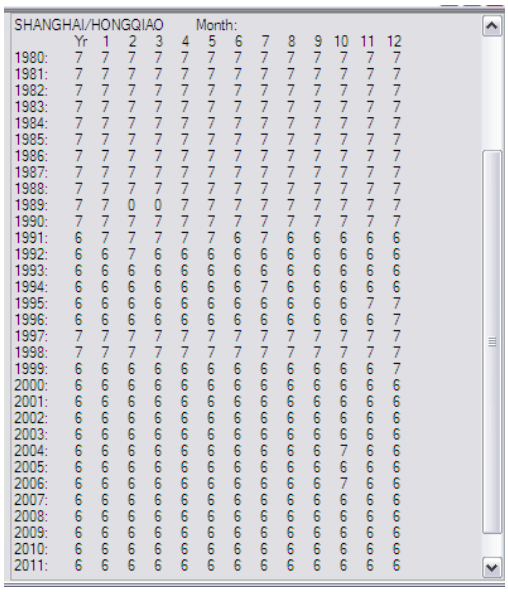
Click a single or any combination (using Ctrl- or Shift-click) of values, time modes or stations, then access the ***context menu*** by right-clicking anywhere in station list is as shown:



- **Analyse (Basic):** Will show in the output panel how much data is available for charting: Complete years, partial years (giving percentage of completeness) and number of years with no data.

- **Analyse (Detailed):** (screenshot) Shows a matrix of how many *values* (Tmax, Tmin, dew point etc.) are suitable for charting. ("Suitable" are values for which there are more than 90% readings.) The number shown is the *count* of suitable values; there are a total of 7 possible values (Tmin, Tmax, Tmean, DewPoint, Rain, WindSpeed and WindSpeedMax.

  Therefore a "**7**" means all 7 values have sufficient data for this month/year. "**0**" means no value has a complete set of readings. Any number in between means that some values are missing. (E.g. temperatures are often recorded while dew point and wind speeds are occasionally not. You will have to plot the graphs to find out which values are available.



- **(Delete):** This will remove the calculated averages for the selected station(s), effectively removing the ability to plot this station. The station will no longer show in the list. This function is for maintenance and diagnostics only, as it leaves the raw data in the Hothaps database. If you want to remove a station from the Hothaps database completely, use the Delete function in the *Manage Daily Data Tab* (page 8). (You can at any stage re-import stations from the NOAA data source.)

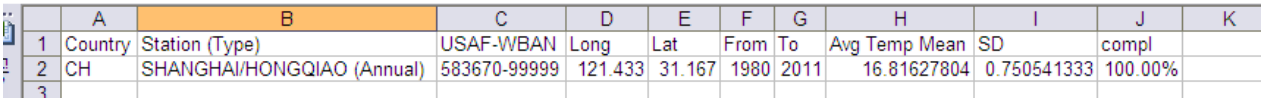
Export Functions

The functions described below, calculate values from the Hothaps database and store the results in the clipboard in a format (tab-delimited plaintext) ready for pasting into a document. The results have a header-row; all calculations contain the following common columns:

Country	Station (Type)	USAF-WBAN	Long	Lat	From	To
CH	SHANG (Jul)	583670-99999	121.433	31.167	1980	2011

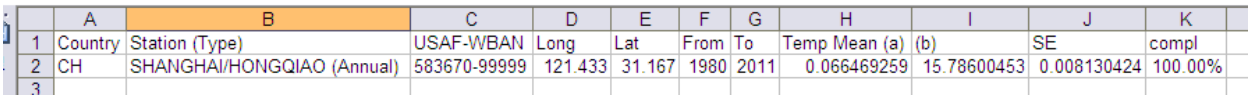
The columns are largely self-explanatory. A "completeness" column ("compl.") is added at the end of each calculated value to indicate the data density of the underlying data (for Average and Regression exports).

- **Export Average:** This function calculates the *average* and for the selected values and outputs this along with the standard deviation (SD), rate of completeness, stations and time modes:



	A	B	C	D	E	F	G	H	I	J	K
1	Country	Station (Type)	USAF-WBAN	Long	Lat	From	To	Avg Temp Mean	SD	compl	
2	CH	SHANGHAI/HONGQIAO (Annual)	583670-99999	121.433	31.167	1980	2011	16.81627804	0.750541333	100.00%	
3											

- **Export Regression (Averages):** Calculates the slope (a), offset/intersect (b) and standard error of the slope (SE) for the selected station(s), and values, based on *annual* or *monthly averages* depending on the time-mode selected. Slope and standard error are given in unit/year. "Unit" here is the obvious unit, i.e. °C in most cases, mm/day and m/s for rainfall and wind speed respectively:



	A	B	C	D	E	F	G	H	I	J	K
1	Country	Station (Type)	USAF-WBAN	Long	Lat	From	To	Temp Mean (a)	(b)	SE	compl
2	CH	SHANGHAI/HONGQIAO (Annual)	583670-99999	121.433	31.167	1980	2011	0.066469259	15.78600453	0.008130424	100.00%
3											

- **Export Regression (Thresholds):** The program will prompt for a threshold value. It will calculate and produce the slope (a), offset/intersect (b) and standard error (SE) for the selected station(s), values and time-modes, relative to the number of days above the specified threshold. The output is comparable to that shown for average regression above. The slope and errors are given in days/year, the intercept is in days.

- **Export Slope Residuals:** This sums the differences between the data values of the last 10, 8, 6 and 4 years and the trend line/slope of the series. The trend is based on the total time period specified in the **Start** and **End Year** boxes at the bottom of the window.

- **Export Avg Residuals:** This sums the differences between the data values of the last 10, 8, 6 and 4 years and the series' average. The average is based on the total time period specified in the **Start** and **End Year** boxes at the bottom of the window.

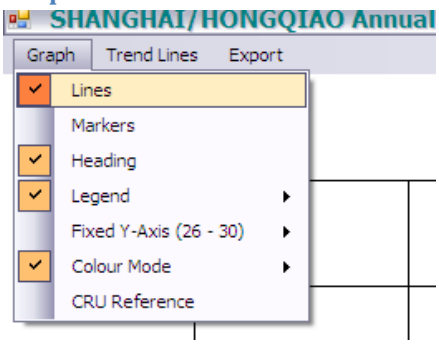
Graph Outputs

The chart feature of the software produces X, Y line charts in separate, resizable windows. You can customise many properties of the chart:

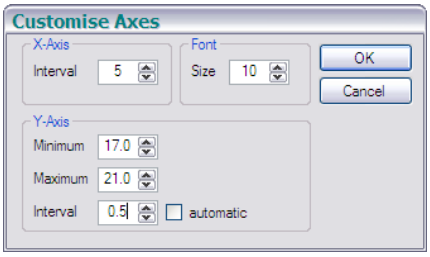
The x-axis (time) is governed by the **Start** and **End Years** entered at the bottom of the main window. The yearly divisions mark the beginning of a year; the annual data points are plotted in the middle of the year. E.g. a data point for the year 2000 appears slightly to the right of the 2000 division.

* Note: If any month or year contains fewer readings than the threshold (currently 90%) of the year or month, that data point will not be plotted. If a graph appears completely blank (heading only), no data is available for the selected combination of values, time modes and station(s). Go to the ***Analysis*** option (see page 8) to find out why.

Graph Menu

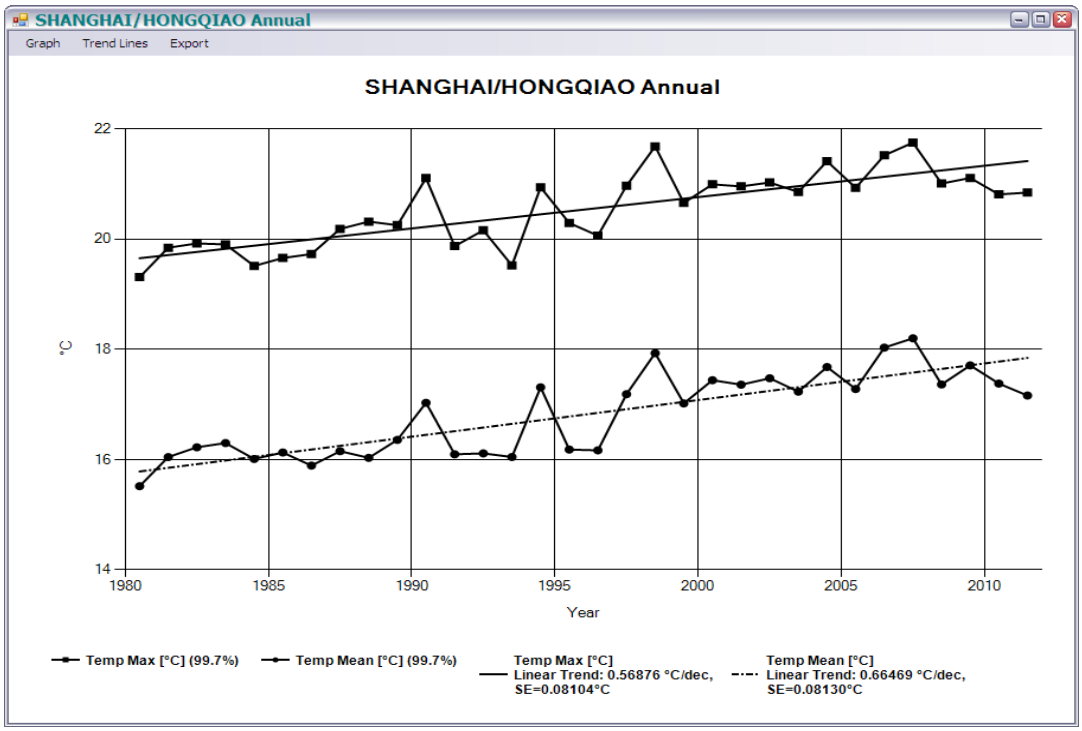


- **Lines, Markers, Heading:** These are ***on/off*** options and quite self-explanatory. Note that turning **Markers *on*** may show data points in patchy data series that are not visible in Lines-only mode. Lines will only show if they connect at least 2 existing consecutive data points (years).
- **Legend:** You can turn legends ***on*** or ***off***. If they are ***on***, you can **Customise Legend** with regards to the position and font size.
- **Fixed Y-Axis (NN - MM):** If this option is turned ***off***, the program will derive a suitable range for the Y-axis from the plotting data. If you want to fix the Y-axis (e.g. to produce a number of graphs with the same scaling), turn this option ***on***. You can set the Y-axis's maximum and minimum values and customise both axes' interval and font size in the window shown.

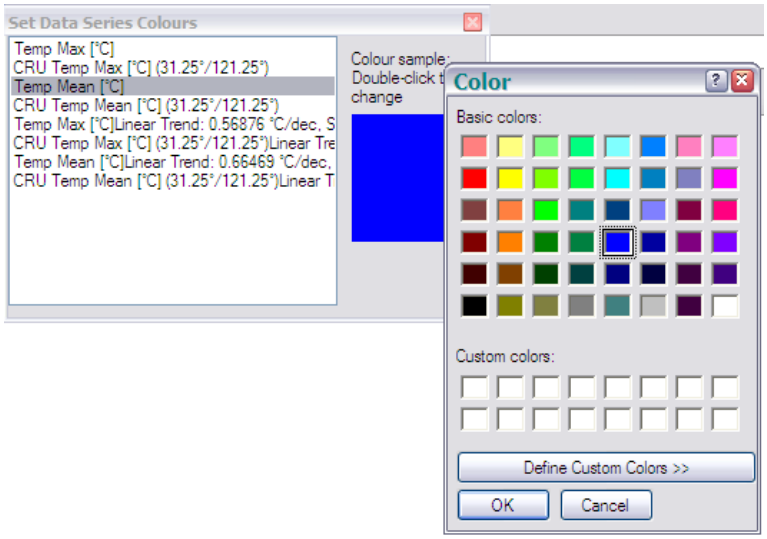


* Note. The X-axis's maximum and minimum are determined by the Start and End Year values entered on the program's main window. You can set the axes' font sizes even if *Fixed Y-Axis* is turned off.

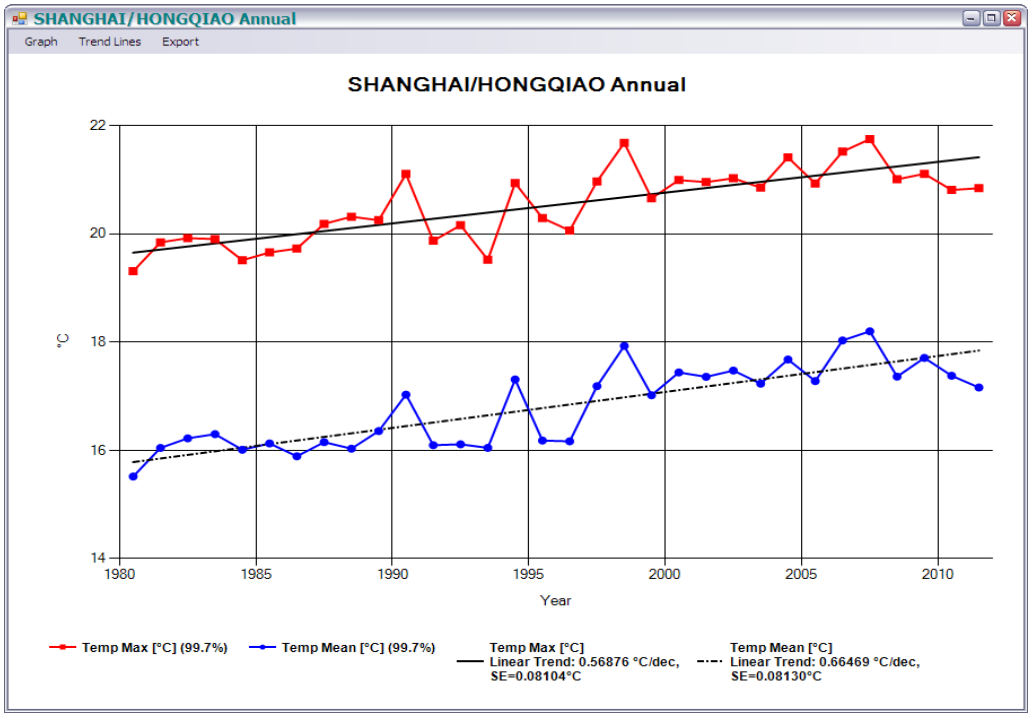
- **Colour Mode:** Turn this option off if you need to publish graphs in black & white.



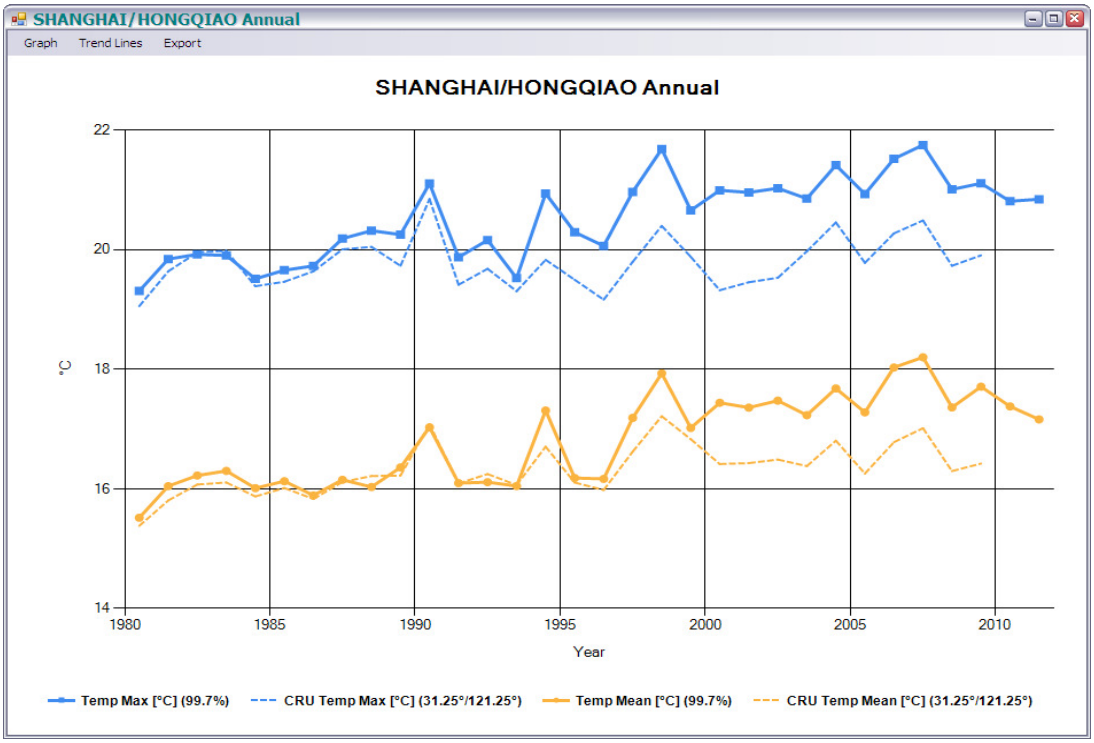
*Note. With colour mode on or off (i.e. even in black & white mode), you can use the Set Colours… submenu to customise the colours for each data series.



A customised graph using black &white as well as coloured elements would look like this:

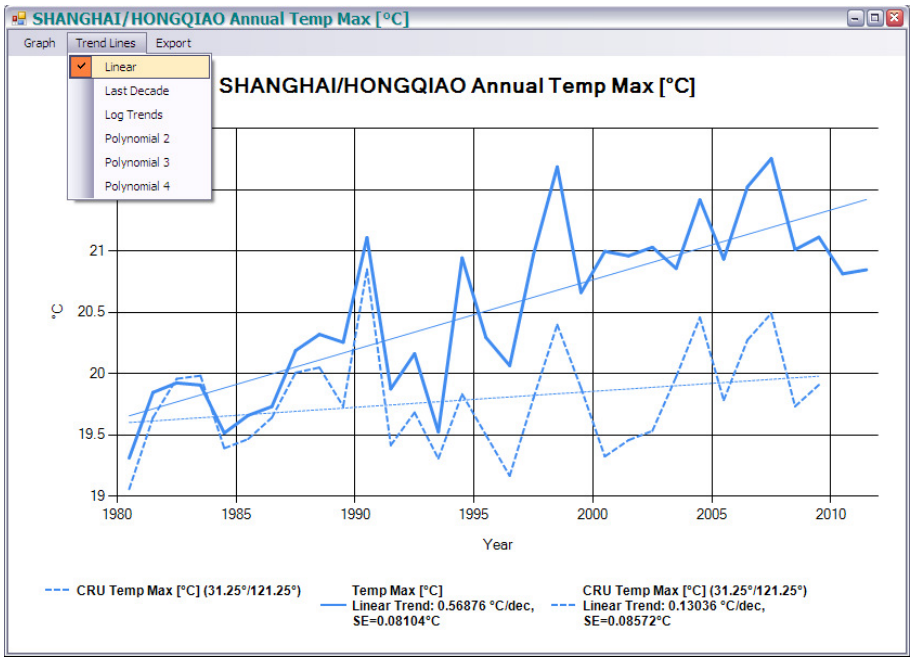


- **CRU Reference:** This option adds CRU reference data to the current graph. CRU (Crown Research Unit, specifically CRU-3, which is used here) provides a validated set of selected values (Tmean, Tmax and dew-point are currently supported by Hothaps-Soft) for all of the earth's land-based locations in a 0.5 degree global grid. When you enable this option, a dotted graph of the nearest CRU grid-square will be shown alongside the original NOAA/GSOD plot:



Trend Lines Menu

You can turn on/off any of the **Linear, Logarithmic, Polynomial and Last Decade (linear)** trend lines by ticking the corresponding menu item. For linear trends slope and Standard Error are shown in the legend. If CRU reference graphs are turned on, trend lines are shown for these as well:



Export Menu

You can export charts as bitmap files in **JPG** or **PNG** format. While JPG is popular, the PNG format uses lossless graphic file compression and is the preferred format for line graphs. The program will prompt for the location of the files and remembers your preference. The file name is taken from the chart's heading.

*Note. The resolution of exported graphic equals the current display size. So, if you resize the window the resulting graphic file will also vary. If you need to export a uniform set of graphs for publication, either stick to the default size of each chart window (i.e. do not resize windows) or maximise each chart window before exporting.

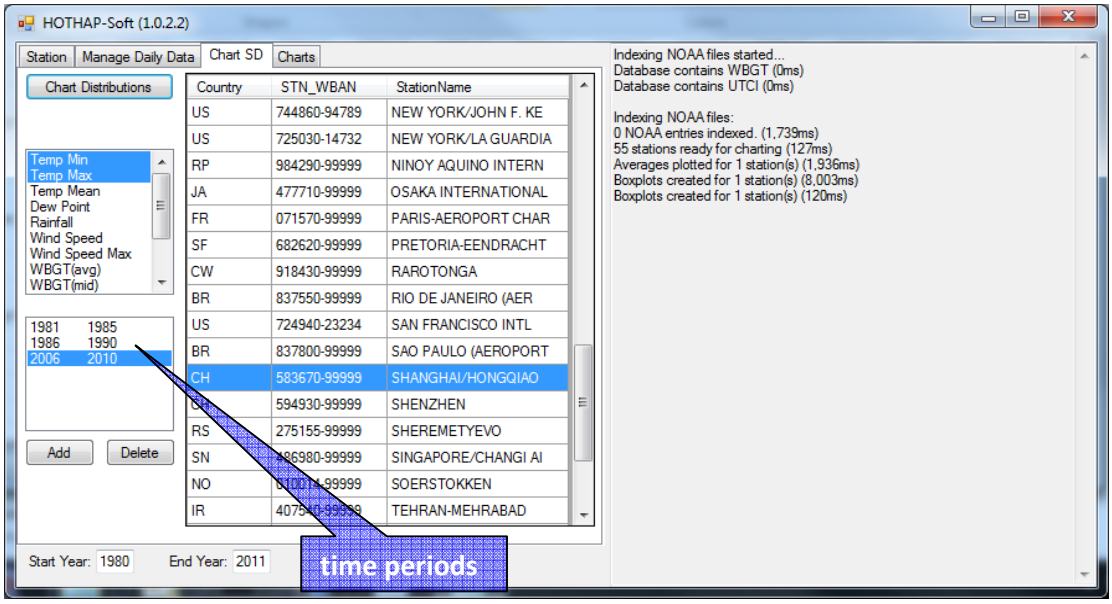
You can also export the chart's underlying **Numeric** data. If you chose this option you will be prompted to select the target folder. The comma-delimited text file contains all data points currently displayed. The file name is derived from the chart title. For the example chart above (SHANGHAI/HONGQIAO, Tmax, with CRU and trend-lines turned on) you would get the following output when opened in Excel:

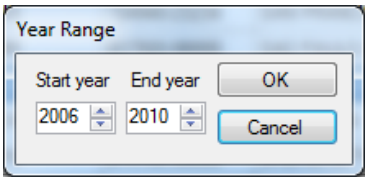
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	SHANGHAI/HONGQIAO Annual Temp Max [°C]													
2														
3	Temp Max [°C]													
4	X [year]	1980.5	1981.5	1982.5	1983.5	1984.5	1985.5	1986.5	1987.5	1988.5	1989.5	1990.5	1991.5	1992.5
5	Y [°C]	19.3121	19.8466	19.9242	19.9067	19.5159	19.6595	19.7315	20.1884	20.3201	20.2551	21.1096	19.8753	20.1627
6														
7	CRU Temp Max [°C] (31.25°/121.25°)													
8	X [year]	1980.5	1981.5	1982.5	1983.5	1984.5	1985.5	1986.5	1987.5	1988.5	1989.5	1990.5	1991.5	1992.5
9	Y [°C]	19.0583	19.6417	19.9583	19.9833	19.3917	19.4667	19.6417	20.0083	20.05	19.7333	20.85	19.4167	19.6833
10														
11	Temp Max [°C] Linear Trend: 0.56876 °C/dec, SE=0.08104°C													
12	X [year]	1980.5	2011.5											
13	Y [°C]	19.65614	21.41929											
14														
15	CRU Temp Max [°C] (31.25°/121.25°) Linear Trend: 0.13036 °C/dec, SE=0.08572°C													
16	X [year]	1980.5	2009.5											
17	Y [°C]	19.60152	19.97957											

Since the chart included 4 graphs, you get 4 sets of data rows. Note that linear trends only consist of 2 data points.

Charts SD Tab

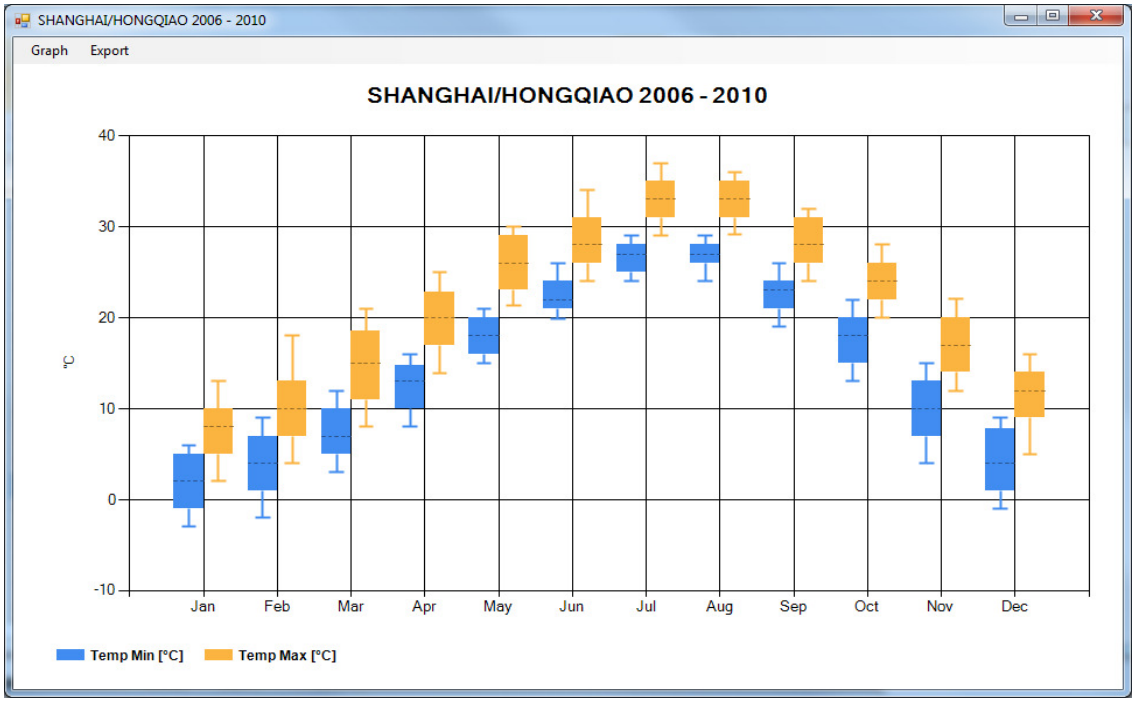
This feature allows you to visualise the median, average and the distribution of the underlying data. You can choose multiple station(s), value(s) to display (e.g. temperatures, heat indexes) and select or create time periods for which to carry out the analysis:





In order to **Add** or **Delete** a ***time period***, click the corresponding button. You can **edit** a time period **by double-clicking** on it. You edit the time period (year range) in this window:

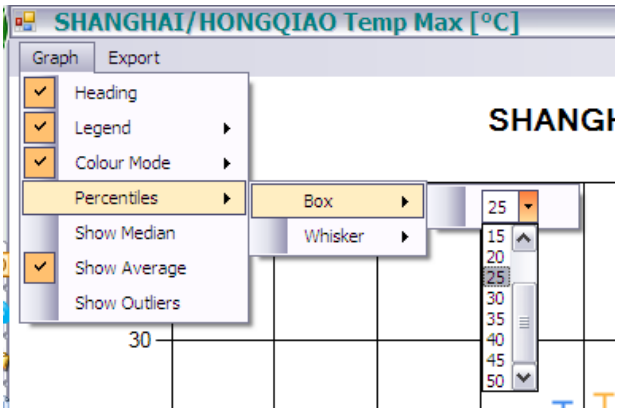
After making your choices click the **Chart Distributions** button to produce a graphic like this:

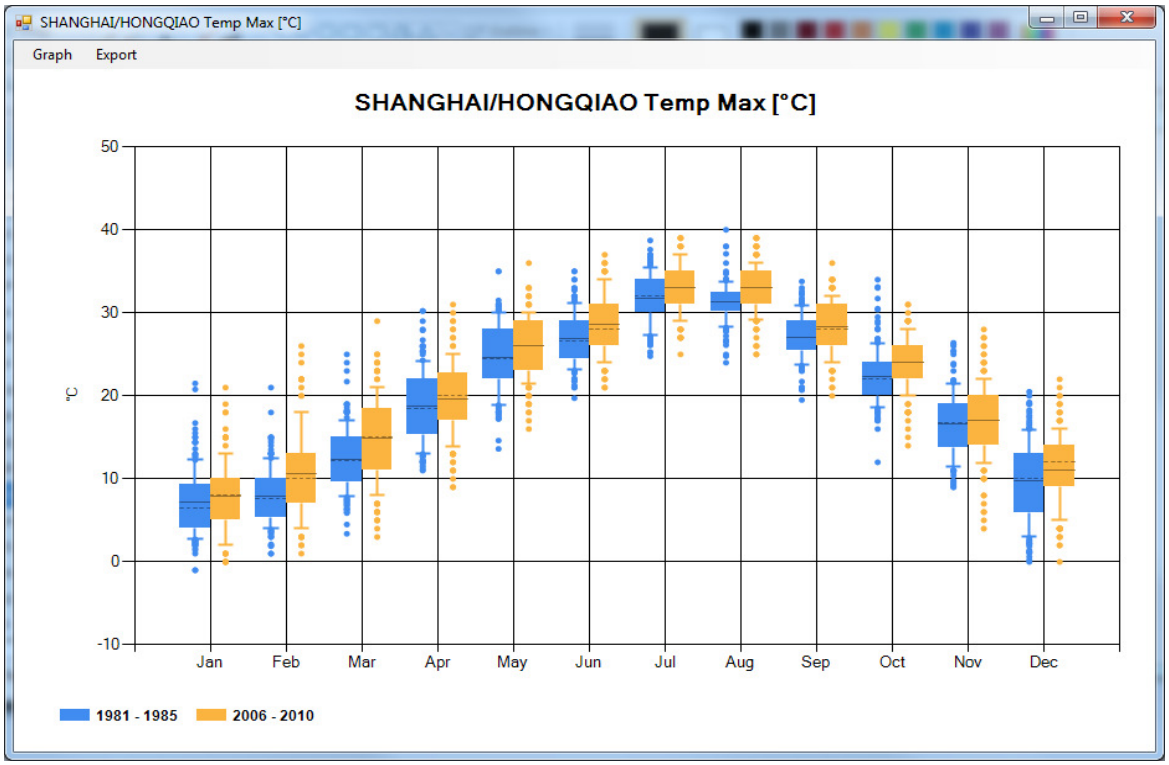


This chart shows box-plots for the two chosen temperatures. The ***median is displayed as a dotted line***, the ***box showing the upper and lower quartile*** and the ***whiskers the 9th and 91st percentile***.

Graph Menu

The Graph menu features Heading, Legend and Colour Mode settings described on page 12ff. In addition you can customise the percentiles and also turn on features like ***Median***, ***Average*** (mean) and ***Outliers***. The chart below shows mean, median plus outliers for Tmax for two different time periods:





Export Menu

The Export menu allows saving the chart as bitmap files in **JPG** or **PNG** format. For details on exporting charts see the notes on page 15.